by the procephalic lobes. The position to be occupied by the myriapods can only be decided by further study.

As will be seen, the points requiring further investigation are many. We at the same time know more and less of the arthropods than of any other group of the animal kingdom, unless it be of the birds. The literature descriptive of the species of insects is enormous, but when one tries, for the purpose of exact comparison, to find out from books some of the simplest points of tracheate anatomy, he is met with only vague and generalized statements or with no information at all. It may be that further study will show that the conclusions reached above are founded on insufficient data, but we think it must be admitted that so far as Crustacea, Arachnida, Limulus and the hexapods are concerned, the points here made are well sustained by our present knowledge. What is especially needed is a more exact knowledge of the arthropodan brain. The papers of Newton, Dietl, Flögel, Brant and others are good, so far as they go, but unfortunately they leave many and the most important points undecided. The same may be said of almost every other point in arthropodan anatomy except the morphology of the appendages, and even on this point much work remains to be done.

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HOW THE PITCHER PLANT GOT ITS LEAVES.

BY JOSEPH F. JAMES.

OF the many curious plants which have been given to the world by America, the pitcher plants are among the oddest. They form a family which belongs entirely to the new world, where the species are widely dispersed. One of them is found in South America, one in California, while the others are natives of the Atlantic seaboard. A single one of these extends northwestward to Minnesota and British America. The feature which is common to these widely-scattered forms is the hollow leaf, making a sort of pitcher into which insects fly or fall or walk.

When a leaf departs as far from the normal shape as does the leaf of the Sarracenia, it is always interesting work to try to discover the causes which have lead to the divergence. To do this it is necessary to go far back in the history of the world and find an ancestral leaf from which it could have come. This necessitates the examination of the various allies and relatives of the

plants, for by so doing it is often possible to find the line along which they have descended. It seldom happens that all traces of this line have been destroyed. Here and there a faint or obscure mark gives a clue; one thing leads to another, until at last it becomes easy to trace the line of development to the original starting point. To do this it will first be necessary to give some account of the pitcher plants now living in the new world.

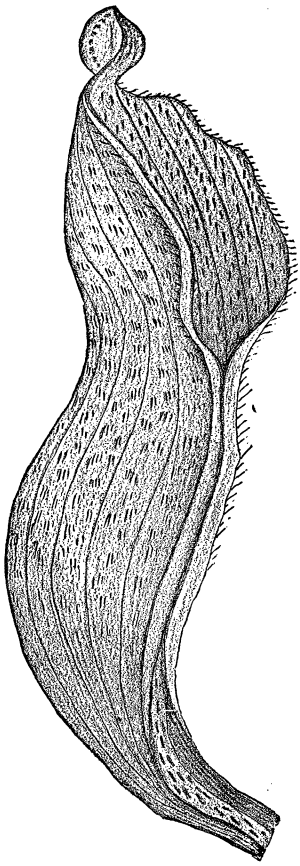

Fig. 1.

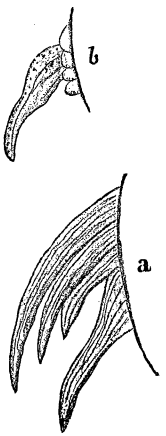

Fig. 2.

FIG. 1.—Leaf of Heliamphora.
FIG. 2.—Hairs of Heliamphora; *b*, from base; *a*, from top.

The simplest form of leaf in the family is found in Heliamphora, a native of Venezuela in South America. It is a hollow tube with a narrow opening extending nearly one-fourth the way to the bottom, and with a small rudimentary hood at the top (Fig. 1). Nearly the whole of the interior of the leaf is lined with hairs, those at the bottom long and slender, and those at the top short and thick (Fig. 2). They do not seem to be either

secreting or absorbing hairs, but serve simply to prevent the escape of insects which have once found their way inside. This may be regarded as the nearest living equivalent of the original and ancestral form, but even it has, of course, been greatly modified to suit altered conditions.

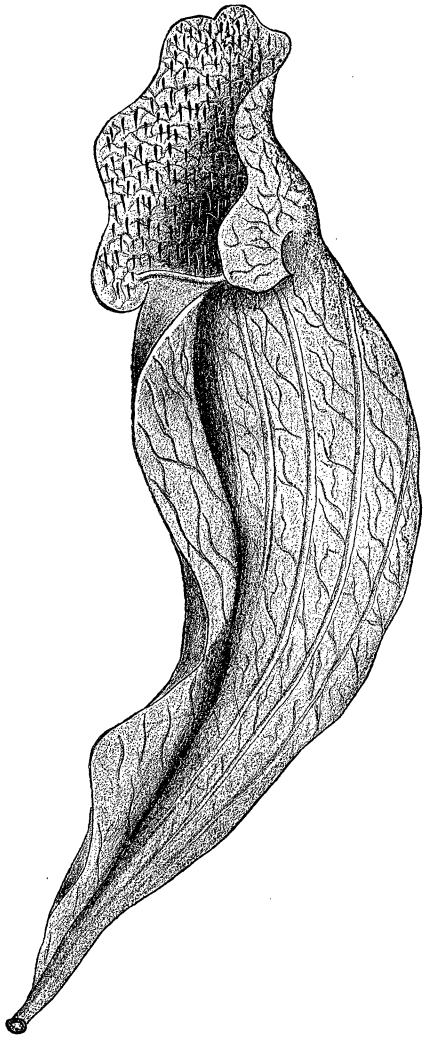

FIG. 3.—Leaf of *Sarracenia purpurea*.

Next in order, but a little more modified, comes the widely dispersed Side-saddle flower (*Sarracenia purpurea*) of the bogs of the Eastern and Northern United States. In this species the leaf forms a more perfect tube, open only at the top, and surmounted

on one side by an upright hood (Fig. 3), the inner surface of which is thickly covered with short stiff hairs, all pointing downwards. The interior surface at the bottom of the hollow is lined with slender bristles (Fig. 4). These extend about one-third of the way up. Then comes a perfectly smooth, glaucous surface, extending another third of the way, and above it is another set of hairs similar to those on the hood. In this leaf there is a marked advance in development over the first one. The hollow is more complete; the hood is larger and more conspicuous and attractive; the smooth surface at the center of the hollow is a more effectual safeguard against the escape of insects, and the plant is in every way better adapted to secure insect prey. Still the pitcher is open to the rain, secretes little or no nectar, and absorbs the juices of the insects it captures in the form of a liquid manure only.

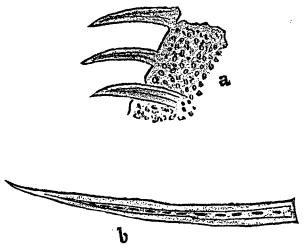

FIG. 4.—Hairs of *Sarracenia purpurea*; *b*, base; *a*, top.

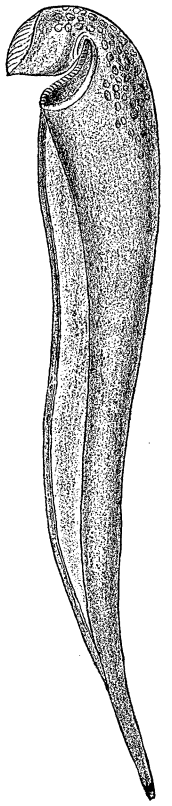

FIG. 5.—Leaf of *Sarracenia variolaris*.

The next step in advance is found in a southern species of the genus with larger and more upright leaves, known as *Sarracenia flava*. The arrangement of the hairs in the interior of the leaf is the same; but a saccharine secretion just below the hood shows a marked difference, and is a more effectual lure to insects than merely a colored surface such as there is in the species previously referred to. The provisions for the retention of insects are equally good in both species, but in the *flava* a secretion of honey acts as a bait. It seems to possess, too, a slight trace of a deleterious quality.

The fourth round of the ladder is *Sarracenia variolaris* (Fig. 5), and here is found a wonderful advance in structure. In the first place the hood bends over the orifice of the leaf and shuts out all rain. Secondly, the hood is marked on the posterior portion with white translucent spots and reticulations, and honey is there secreted. Thirdly, the fine velvety pubescence extends one-third way down the pitcher, and then the hairs become longer, coarser

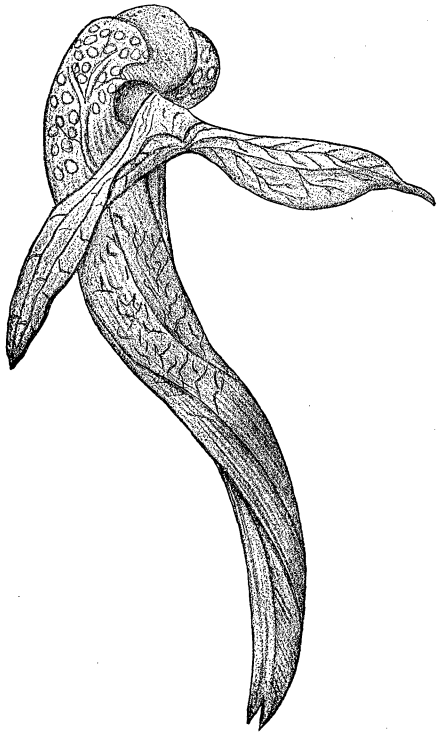

Fig. 6.

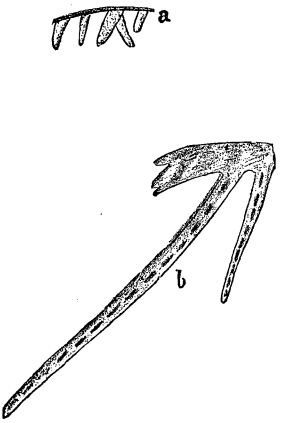

Fig. 7.

FIG. 6.—Leaf of Darlingtonia. FIG. 7.—Hairs of Darlingtonia; *b*, base; *a*, top.

and more bristly as the tube narrows. Fourthly, a secretion is formed at the bottom of the pitcher which has the peculiar property of asphyxiating insects so unfortunate as to fall into it Fifthly, there is found to be a honey-baited pathway running from the ground up along the wing of the leaf to the hood, and a short way into the orifice.

These are many and curious changes. A marked advance

over the open, honeyless pitcher of *S. purpurea* is at once manifest. But a still further advance is found in Darlingtonia, the third genus of the order and a native of California. In this the leaves are very long, stand upright and have a peculiar twist not found in any other species (Fig. 6). The hood, in addition, forms a vaulted arch, mottled with spots and reticulations. The only entrance to the leaf is from below, and on each side of this entrance is a long appendage, the whole likened to a fish tail. The inside of this secretes honey and is covered with hairs. The interior of the pitcher is lined with vast numbers of hairs, which become longer and more bristly toward the bottom (Fig. 7). A secretion is found here that has the power of decomposing the bodies of the insects which have been entrapped. On the outside, running along the wing, from the ground to the orifice, is a honey pathway which lures creeping insects to their destruction. The wings or fish-tail, at the top of the pitcher, attract flying ones.

In these species of plants there is a regular gradation from the simple to the complex. From the Heliamphora with its open pitcher and small hood, to the *Sarracenia purpurea* with upright, less open pitcher and larger hood; thence to the *S. variolaris* through several stages of less complexity, with its almost closed pitcher, power of secreting honey and digestive fluid; then to the more remarkable Darlingtonia, with its large twisted leaves, with vaulted hoods and fish-tail appendages, decomposing fluid and honey-secreting apparatus. Scarcely any of the steps showing the progress are needed to complete the line of development. It can be traced directly from Heliamphora to Darlingtonia, and it is only necessary to have an ancestral form from which to start to have a complete pedigree.

It seems probable that the water-lily family and the pitcher-plant family had a single ancestor in common. This ancestor was aquatic, or at least an inhabitant of swampy places. It had small, probably peltate, perhaps reniform leaves, and these had hollow petioles. The inner space was lined with hairs as are now the inner surfaces of the stems of Nymphæa and its allies; it had a four or five parted flower, with many stamens and a broad stigma.

From such an ancestor came two or three branches. One of these developed into plants having an aquatic habit, large leaves

and long petioles, and peduncles like those which are found at present in the water-lilies. The other branch diverged to form plants living in boggy or swampy grounds, with pitcher-like leaves whose insectivorous proclivities were developed later on.

The development of the members of the water-lily family from this hypothetical ancestor can be accounted for thus. The aquatic habit must be confirmed, the depth of water increased, the leaves grow larger and the change is complete. But to transform a peltate or reniform leaf into a pitcher requires much more modification. Suppose, however, that water lodging on the upper surfaces of some leaves was retained there; and that in this water insects were caught and drowned. Suppose the constant presence of the water caused the decay of the substance of the leaf at its insertion on the petiole and allowed the water to penetrate the hollow. This liquid manure might assist the plant in its growth. The habit of catching water by means of a peculiarly cup-like leaf, would be transmitted from generation to generation. Each successive one would have larger and larger petiolar spaces, and correspondingly smaller leaves. And this because the liquid manure supplied directly to the root would enable the plant to do with less and less leaf surface as the nutriment was more and more fully elaborated; until finally the petiole would have grown into a hollow pitcher-like affair, and the leaf-blade would have dwindled to a rudiment.

The primitive pitcher plant was probably but little less specialized than the least one now known. This one has already been described under Heliamphora. The various modifications of structure incident to change of form now come under consideration.

The internal hairs of modern water-lilies were likely represented in the ancient form from which they are descended. In species now living these hairs are stellate, with from three to five arms or projections (Fig. 8), and they thickly line the interior spaces of the petioles of leaves and the peduncles of flowers. Exposure to air and adaptation to altered conditions would naturally cause a change of form. They doubtless lost first one and then another

FIG. 8.—Internal hairs of water-lily.

projection, till they were reduced to a single one. This one would be, at first, of the same size and shape the whole length of the pitcher. Then, in time, as it was found that those at the bottom would not need to be so strong, they would become longer and more slender, while the uppermost ones would be stiff and harsh to more effectually prevent the crawling up of insects. As the specialization proceeded, a less number of hairs would be required and a smooth space near the center of the wall of the leaf would be found a still more effective guard against the escape of the prey.

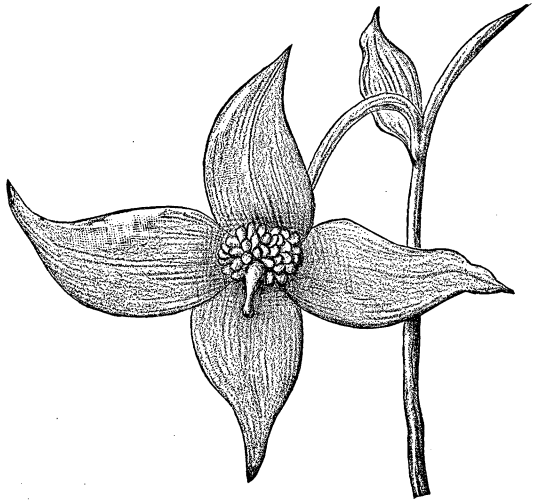

FIG. 9.—Heliamphora.

As soon as the capture of insects became a necessary part of the existence of the plant, or even an advantage to it, honey would be developed to serve as an attraction. This, from at first a merely sweet secretion, would acquire, if it served a useful end, a character calculated to retain the insect. If, however, the honey had too bad an effect, the end in view would be defeated, for it would in time be rendered unattractive. For insects would in their turn, become modified to resist the temptation. So then the next step in the onward march would be to keep the honey of the lure pure, but to modify the character of the secretion at

the bottom of the pitcher so as to retain and eventually convert the insects caught into nutritious material for the plant. This secretion would become a further necessity, and its character would be otherwise changed when, by a change in the nature of the hood, rain was excluded from the cavity. Finally, as a further lure to insects appendages brightly or curiously colored would arise and assume a form calculated to attract them.

That these were the steps leading from the simplest to the most complex form of pitcher is shown in the actual forms living to-day. There can hardly be a better illustration of the theory of descent with modification than is found in this one family. It becomes, therefore, a matter of peculiar interest to still further continue the study, and to investigate the causes which led to the peculiarities of the flowers they possess, and likewise to study the reasons for their present geographical distribution.

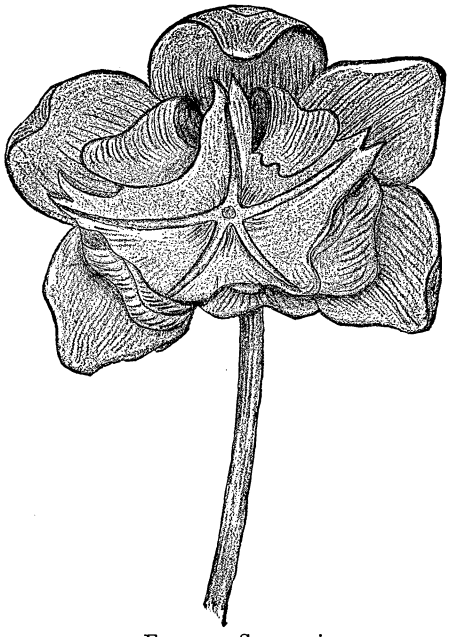

FIG. 10.—Sarracenia.

The flowers of Heliamphora are described as being regular, with four, five or perhaps, at times, six sepals, no petals, an indefinable number of stamens, and a single, entire pistil (Fig. 9). There are one or two flowers on a bracted scape. In the flowers of all the species of Sarracenia a peculiar modification of the pistil is observed. Along with the five sepals and five petals, it is found that the pistil has assumed a broad, umbrella-like shape (Fig. 10) with the stigmatic surfaces at the ends of the rays. These are five in number and extend upwards as the flower hangs. A single flower is at the top of a naked scape. The flower of Darlingtonia (Fig. 11) is solitary at the top of a bracted scape, has five sepals and five petals, only twelve or fifteen stamens and a style with a five-rayed stigma.

In the first of these, the South American form, is probably to be found the nearest approach to the original type of flower. The single floral envelope, indefinite number of stamens and simple pistil, seem to indicate a comparatively unspecialized form, which corresponds to the simplicity of the leaves. In the modern Nymphæa or water-lily, there is a great number of petals, but these could be readily regarded as some of the numerous stamens of a few-sepaled or petaled flower which have been transformed into petals. In the ovary of Nuphar (spatter dock) there is an approach to the simple ovary of Heliamphora, accompanied, to be sure, by modifications which may be regarded as necessitated by an aquatic life. So that it does not require much to assume that in the flowers as in the leaves, the water-lilies and the pitcher plants are closely allied.

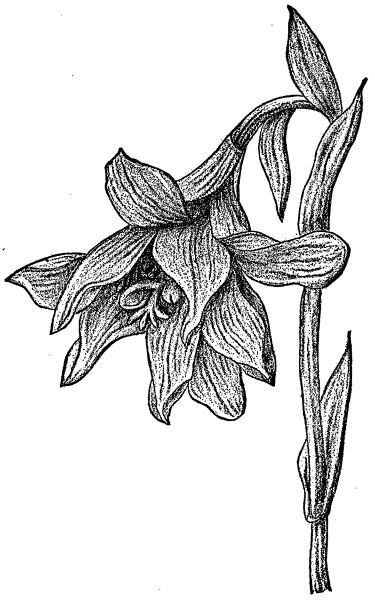

FIG. 11.—Darlingtonia.

The umbrella-like stigma of the side-saddle flower, as well as its whole arrangement, is to be regarded as a modification incident to cross-fertilization; for in these plants seed is not perfected otherwise. On this account alone it would be expected to diverge widely from the primitive form. But there is, in the closely allied poppy family, an approach to this spreading umbrella-like stigma, whose whole large expansion may undoubtedly be referred to the necessity for cross-fertilization.

Lastly, in the Darlingtonia the flower is also greatly modified. This time the change has taken place in accordance with changes in the leaves. The analogy between the fish-tail appendages of the leaves and the peculiarly spreading petals of the flower has been pointed out by Dr. Hooker. As both are of the same color and bear considerable resemblance to each other, he suggests that their development has proceeded together, and that while

one attracts the insects for purposes of fertilization, the other, by its imitative powers draws the visitor to it and is thus enabled to feed itself. Nor is such a suggestion an unreasonable one when the highly specialized condition of the plant is considered. If once a hint in that direction showed itself, and any benefit was thereby derived, it may be considered as certain that the direction would be persevered in until both leaves and flowers had departed very far from the original and normal type. This is exactly what has happened.

Coming finally to the geographical distribution of the order, the facts show plainly how one could have been derived from the other. The original home of all was most likely in South America, where one species still lingers. This original form may be imagined as conveyed from its place of origin to the south coast of what is now the United States, most likely by means of the Gulf Stream. Finding a suitable place for living, the somewhat changed conditions would have modified the emigrant into a plant with a leaf like *S. purpurea.* This once fairly established spread all over the country where there were favorable conditions for its growth. If we imagine this dispersion to have been during the continuance of the Tertiary period, there would have been ample time for great modification to take place. Then it was, in all likelihood, that the Darlingtonia began to develop in its own way. After a long period of time the Tertiary epoch was brought to a close. A great change came over the face of the country, and many of the intermediate forms between Sarracenia and Darlingtonia became extinct. Change in climate and in conditions produced by the glaciers which covered the country at one time was an efficient agent of extinction. At the same time the unextinguished forms would have continued to become modified in various ways until they became as they are now found.

The history of this one family, peculiarly circumstanced as it is, shows the possible origin of a number of forms from one common ancestor, different though they are from each other at present. In every part can be traced the workings of evolution. In leaf and in flower the steps can be followed. Even in the geographical distribution of the living species it can be seen. In some families of plants the steps are not so plain because encumbered by a larger number of generic and specific forms; but

could the gaps be filled in any one species or order, the line of descent might be followed through the ages to one common and generalized type. The varied forms to which that type gave rise are seen in the different genera of different natural orders. The time is far distant when all these can be traced step by step to their remote origin. But every little adds, and eventually a monument will be raised which will tell how, and perhaps when, each individual plant reached its present state of perfection or degeneracy.

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AN ADIRONDACK NATIONAL PARK.

BY WILLIAM HOSEA BALLOU.

A PROPOSITION to convert the Adirondack region into a national park, ought only to need suggestion. The only portion of the public domain which has been set aside as a national park is located in the distant mountain regions of Montana and Wyoming. East of the Rockies and within a territory of four million thickly populated square miles, not a single national breathing ground exists. In the great Empire State lies an elevated country of vast area, as lovely as the mind of man has mental imagery to conceive. It stands to-day the prey of timber thieves and game butchers, so neglected by the State that its boundary lines have been lost, its forests denuded, its waters left to evaporation and outrage, and its maintenance denied of all but the smallest pittance. It is the particular surface of the globe that gives one a glimpse through the corridors of time. It is a part of the cradle of the earth. Here are blue-gray hypersthene and contorted gneiss rocks—the first forms in nature's attempts at world building. Before organisms came into existence these rocks formed their part in the stable foundation of the earth. The Adirondack region, then, is grandparent to the remainder of the globe. The Hudson, which rises in its clouds, is perhaps the oldest river in existence, being the ancient outlet of the Great Lakes' ancestor, and hence the grandparent of waters. Will any one say that the Government of the United States ought not to be charged with the care of the portions of these aged relics which a great State has given over to weeds and bandits?

Two great watersheds lie within the State of New York at right angles to each other. They so interlock that writers have